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# Henry Ford Hospital

DIVISION OF NEUROLOGY
WILLIAM C. NOSHAY, M.D.
J. DANA DARNLEY, M.D.
KENNETH H. KAPPHAHN, M.D.
H. F. LABSAN, M.D.

2799 WEST GRAND BOULEVARD
DETROIT, MICHIGAN 48202

DEPARTMENT OF NEUROLOGY AND PSYCHIATRY
LORNE D. PROCTOR, M.D.

DIVISION OF PSYCHIATRY
EUGENE J. ALEXANDER, M.D.
WALTER L. GRAHAM, JR., M.D.
ROBERT R. SCHOPBACH, M.D.
ANDREAS MARCOTTY, M.D.
GERALD G. POPE, M.D.
DONAL L. WHITE, M.D.
SECTION OF PSYCHOLOGY
THEODORE E. CADELL, PH.D.
OSCAR SIMPSON, M.A.
KERRY NELDER, M.A.

[redacted]

November 10, 1963

Winnie M. Morgan, M.D.
Report Control Officer
Grants and Research Contracts
Office of Space Science
National Aeronautics and Space Administration
Washington 25, D.C.

Re: Voucher No. 8 for Contract NASr-83

Dear Dr. Morgan:

The following is our progress report for the period July 1 to September 30, 1963.

Since commencement of this research project, eighty-three 48 hour test runs have been made and twenty-five of these 48 hour runs were conducted during the last quarter (July through September). To date there have been no changes in test procedures other than the auditory and visual changes in environment. As before, the baseline environmental conditions were medium intensity white noise and medium intensity white light. Eighteen of the orbits were under baseline environmental conditions, the remaining seven orbits were under altered environmental conditions. Seven orbits were conducted in the space couch, and eighteen in the space chair.

A total of twenty-five 48 hour test runs were conducted, being distributed as follows among our trained platoon of five Nemestrina monkeys: NA-3, 6 orbits; NA-4, 6 orbits; NA-5, 5 orbits; NA-6, 7 orbits; and NA-9, 1 orbit. The EEG recording from all of these animals, except NA-3, were taken from superficial electrodes located in the temporal region of their skulls.

Five depth records were made during 4 orbits using NA-3. The usual 1 to 2 cps slow wave activity (usually in bursts) could not be related to behavior by visual scanning. NA-8, following a training orbit, became ill and died in a matter of twelve hours. The gross autopsy report revealed no cause of death, and the animal was examined on several occasions during the twelve hour illness, preceding death, with no clinical explanation for the progressive

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increase in respiratory distress and weakness. The microscopic slides of the various tissues, particularly the brain, will be available during the next quarter.

Further telemetric development for EEG transmitting and recording were conducted on NA-7, and these results are set out in the report on telemetry. NA-9 completed its training during this quarter and has completed one orbit. Five new Nemestrina monkeys have proceeded through their isolation period, and are now beginning training. These animals should constitute the remainder of the animals necessary for our project.

The two chimpanzees in our colony have maintained good health with appropriate weight increase during this past quarter, and the training of these animals has progressed to the point of them beginning to accept the space chair. NAC-1 (Fletcher) is progressing the most rapidly, but NAC-2 (Kenny) is requiring special attention to his habit of biting his upper limbs when chaired. NAC-1 (Fletcher) has commenced with the presentation of the test patterns, but as yet is not to the point where his response is other than that of chance.

<u>Performance Data</u>

During this quarter it became obvious that, probably due to continued conditioning and learning processes, a number of the test animals showed a continued high performance level throughout the entire 48 hour orbit (figures 3, 4, and 5).

We have graphed, during eighteen orbits under standard environment, the response output (total response - right or wrong), figure 1; total response output and percent correct responses as a function of alerting cue duration, figure 2 and 5; percent correct responses using the successive reversals test, figure 3; and percent correct responses using the delayed response test, figure 4. Similarly the total response output on single orbits (48 hours) have been graphed under changed environmental states (visual and auditory), figures 6, 7, and 8.

A significant difference in performance as a function of alerting cue duration, observed earlier, was not apparent in the orbits this quarter; no doubt due to the continued high performance discussed above, figures 2 and 5. Probably for a similar reason a decrement in performance on delayed response and reversal tests over time in the 48 hour orbit has not been observed, figures 3 and 4. It was thus desired to increase task difficulty and achieve a lower baseline performance so that facilitation as well as decremental effects could be observed in the special environments. Therefore, in the present quarter, attempts have been made to increase task difficulty, and it is expected that testing procedures now being initiated will prove satisfactory. To this end, in the reversal task, frequency of reversals and stimulus similarity have been varied, and in the delayed response task the nature of the informational event and the cues available during the delay have been varied.

It was expected that sudden introduction of new environments would be sufficiently disturbing to the animals that performance in those environments selected for early orbits of this phase of the project would be subject to factors, such as fear, not to be present in the same magnitude in environments used later in this phase. Therefore, some testing in special environments has been done while working on modifications of test procedures to acclimate the animals to such special environments.

Significant response decrement was observed in two of the three special environements used this quarter, figures 6, 7, and 8. As only three orbits have been made under such environments, it is too early to draw any conclusions.

When procedures are finalized, testing will begin in thirty environments which are the possible combinations of six visual and five auditory conditions. Eight monkeys will be used, some half of which will be tested under each condition.

The routine visual evaluation of the records of twenty-five orbits was made and the presence of theta activity in the pre, during and post-performance periods in both those animals that performed well and in the sessions in which there was poor performance were noted. It has become increasingly evident that the post performance EEG data does not warrant computer evaluation at this time in view of the funds available for this part of the project. Therefore, in August we discontinued placing this portion of the EEG on electromagnetic tape. Should we wish to review the post performance portion of these records, they will be available on the EEG paper records taken on all orbits.

The major emphasis on EEG evaluation in this quarter was the use of the IBM 1620 computer employing a system that required analogue recording on an FM tape recorder with subsequent digitization of the analogue signal, and processing on the computer by a program which we had developed in our own laboratory (zero scanning). This program cumulatively sums the amount of time that the 4 to 7 per second EEG activity was present during any portion of the record, and these sums are plotted for each period during the 48 hour orbit. We are enclosing one figure (9) that shows the plot of an entire record of the 48 hour period. The EEG was taken from both the right and left temporal regions of the monkey. This figure shows two features: (1) the symmetry of the two hemispheres is emphasized and (2) this particular record substantiates our impression that theta activity is actually increased during the 3 minute performance period. We used this procedure and the EEG recording of three other orbits, but the information is not complete on these orbits. In some cases we taped only every other test session, and in others equipment failure led to lack of a complete record. We have three other complete orbits in the process of being evaluated by the computer, and these will be included in our next quarterly report.

In addition to the above results, we have also plotted the derivative of the theta activity (figure 10) from test session to test session, and the graph of this derivative seems to be quite sensitive to various features of the behavioral study of the animal. The derivative of the theta activity in the pre-performance period seems to be sensitive to the sound-cueing of the animal that appears just before the test objects are presented. The derivative of the theta activity during the performance period, on the other hand, seems sensitive both to the kind of test the animal is given, and also to his success in performing the test as it is presented, (these are depicted in figure 10). The results on hand at the moment are insufficient to give any positive conclusions. However, we are gathering more data and will subject this to statistical procedures that will give us some definite indication as to the reliability of this method of correlating the EEG and behavior. At the present time, we are recording every other orbit on analogue tape and evaluating these records by means of the computer.

TELEMETRY

I. The results of some experiments which we conducted with the two channel packages referred to in our progress report of April 17, 1963 are reported.

Receiver interaction: The arrangement of equipment for an experiment on receiver interaction is as shown in figure 11. An oscillator (H.P. 204 B) with attenuator pad delivered a 5 c/s signal, 100 micro-volt, peak to peak into both preamplifiers. This signal was amplified and transmitted at 89.0 Mc/s and also at 87.9 Mc/s. The receiver to the left (Heath AJ 31) was tuned to 89.0 Mc/s and its output was displayed on the fourth channel of a Model 5 Grass EEG recorder. The receiver to the right (Heath AJ-31) was tuned to 87.9 Mc/s and its output was displayed on the sixth channel. The peak to peak amplitude of the ink traces thus obtained was measured in mm for 8 conditions as shown in table 1. Conclusion: Spurious radiation from the receiver on the right interferes with the proper function of the receiver on the left if the two receivers are located as close as 6 inches apart. Such interaction is not noticeable if the receivers are more than 2 feet apart.

Transmitter interaction: We also observed undesirable interaction between transmitters when they were mounted adjacent to each other in the two channel package; however, by locating them at opposite ends of the package, ~~axxshownxinxfigurex11x~~ we have overcome this problem.

Dynamic range: The dynamic range of the transmitter-receiver system was determined with an arrangement as in figure 12. With the 350-B attenuator set to 0 db, the amplitude of a 5 c/s sinussoidal signal was adjusted so as to make distortion on the recorder chart just not noticeable. Recordings were then made at db settings of 20, 40, 50, and 60 respectively, each time increasing the recorder sensitivity by a corresponding amount. A fairly clean signal was recorded at 40 db though some noise is noticeable. At 60 db the noise signal, mostly 60 c/s was comparable in amplitude to the 5 c/s signal. We consider this dynamic range adequate.

Frequency response: The frequency response is flat from 1 c/s to 70 c/s and is mainly limited by the Sem-Jacobson pre-amplifier.

Overall performance: The overall performance of the two channel telemetry system is illustrated by the recording in figure 13 which was obtained with the arrangement of equipment in figure 12. A monkey with a platform mounted to its skull, with the intention of accommodating the pre-amp-transmitter package, could not be used for this experiment as with time some bone around the platform mounting screws dissolved, rendering it unsuitable. The experiment was, therefore, carried out with a human volunteer. The third trace from the top is a direct recording from the occipital area ($O_1 - O_2$), the corresponding telemetered signal is shown directly below that. The fifth trace from the top is from central electrodes ($C_3 - C_4$), its corresponding telemetered signal is shown in the sixth trace. This particular experiment lasted for 50 minutes during which no drift of receivers was noticeable.

The transmitter to receiver distance was approximately 8 feet.

<u>II Artiface due to movement</u>:

An experiment was carried out whereby an aluminum box with three resistors (corresponding to the three electrodes from which we record brain activity), and a connector similar to the one used on our monkeys was connected up to the Model 6 EEG recorder instead of a monkey, and the box was shaken to simulate head movement with the recorder turned on. Ideally there should be no evidence of electrical activity on the recorder chart as no signal is generated inside the box. However, activity was present and in order to shed light on its cause we conducted a series of experiments. A definite cause has not been found yet; however, these experiments brought about a lead arrangement which constitutes a considerable improvement over the one used previously. In practice the arrangement has proven to be satisfactory, notwithstanding the fact that the amphenol miniature coaxial cables used are heavier and less flexible than the Grass EEG leads used previously.

<u>III Differential preamplifiers</u>:

With regard to the Litton Systems, Inc. Bio-Amplifiers B-30A mentioned in our report of July 20, 1963, we have the following to report. The transistors of these amplifiers are used in a-typical operating points. Whereas typically the base current is negative; for instance, we measured positive values on all transistors. We suspect that in the design of these units this course was followed in order to keep the current drain to a bare minimum. Though it seems that transistors can be operated in this manner (we measured gains from 400 to 4000 depending on temperature), it makes treatment of the circuit from a theoretical point of view difficult as the transistor manufacturers do not aupply characteristics for non-typical operation. The quality of differential amplifiers depends on the amount of unbalance of symetrically located components. The transistors showed large unbalances in their operating points, and their characteristics and theoretical treatment such as given by R.D. Middlebrook Differential Amplifiers (Wiley) are not applicable for the above mentioned reasons. We will, therefore, abandon these amplifiers for an approach whereby high quality, closely balanced components are used in a manner dictated by theoretical considerations.

Hoping you will find this progress report adequate.

Yours sincerely,

Lorne D. Proctor, M.D.,
Chairman - Department of
Neurology and Psychiatry

LDP/B
Enclosures

PS: Apologies for the delay in submitting this report, but I have been at Ames Research Center in regard to our NASA project.

L.P.

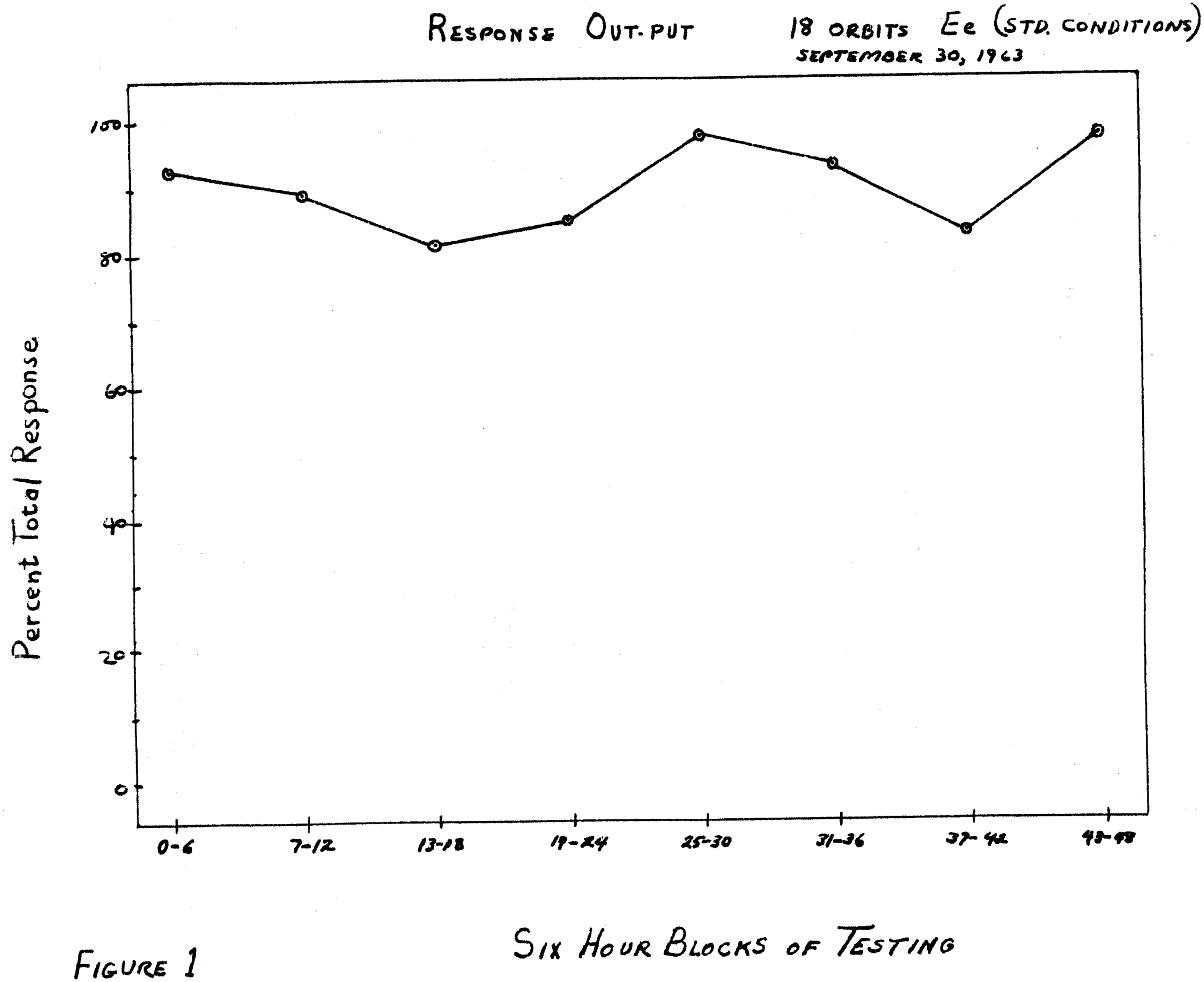
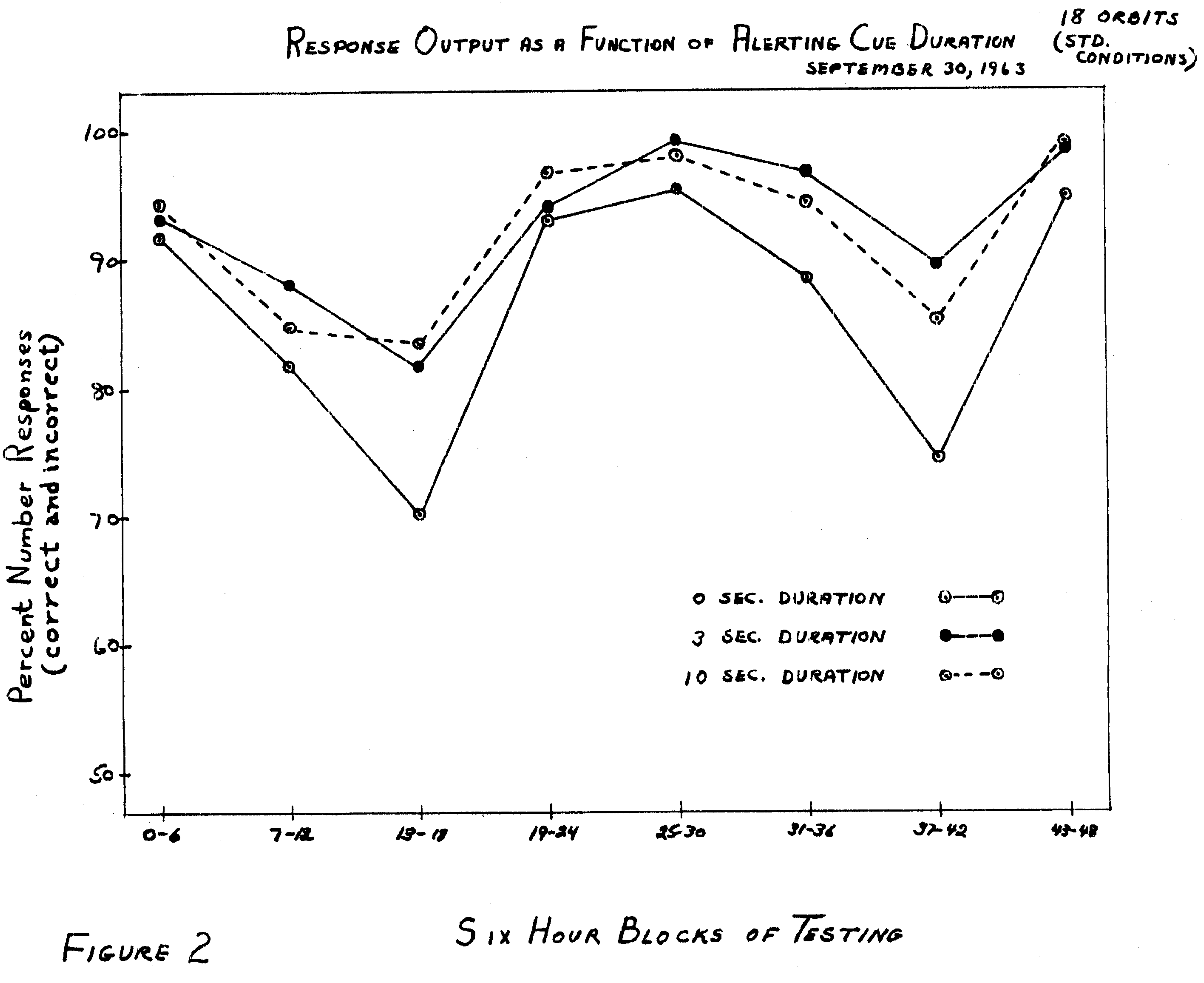

Response Out-put
18 orbits Ee (std. conditions)
September 30, 1963
Percent Total Response
100
80
60
40
20
0
0-6
7-12
13-18
19-24
25-30
31-36
37-42
43-48
Six Hour Blocks of Testing

Figure 1



RESPONSE OUTPUT AS A FUNCTION OF ALERTING CUE DURATION
SEPTEMBER 30, 1963
18 ORBITS (STD. CONDITIONS)
100
90
80
70
60
50
Percent Number Responses (correct and incorrect)
0-6
7-12
13-18
19-24
25-30
31-36
37-42
43-48
0 SEC. DURATION
3 SEC. DURATION
10 SEC. DURATION
SIX HOUR BLOCKS OF TESTING


FIGURE 2

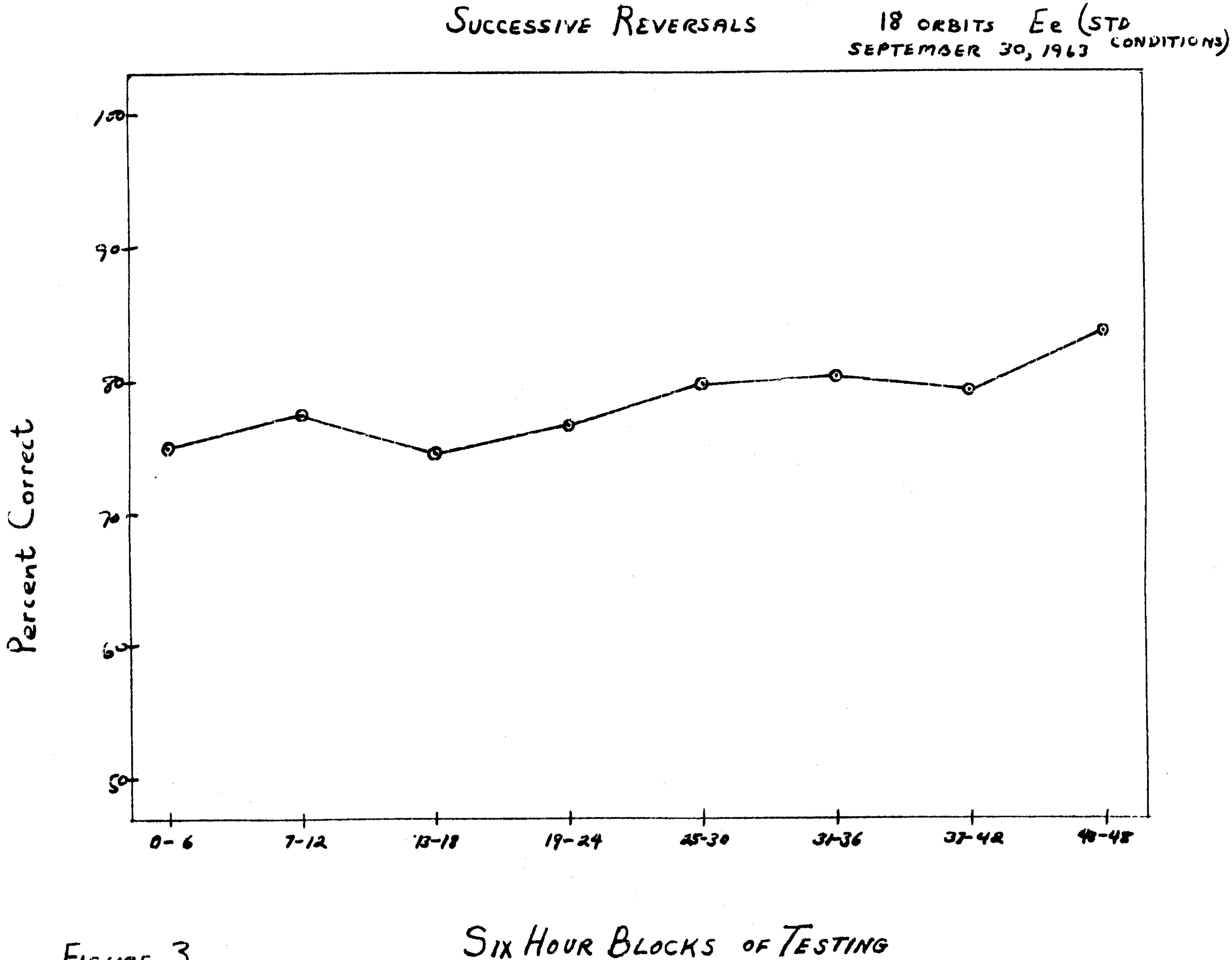

SUCCESSIVE REVERSALS
18 ORBITS Ee (STD CONDITIONS)
SEPTEMBER 30, 1963
100
90
80
70
60
50
Percent Correct
0-6
7-12
13-18
19-24
25-30
31-36
37-42
43-48
SIX HOUR BLOCKS OF TESTING

FIGURE 3

DELAYED RESPONSE 18 ORBITS $E_c$ (STD. CONDITIONS)
SEPTEMBER 30, 1963

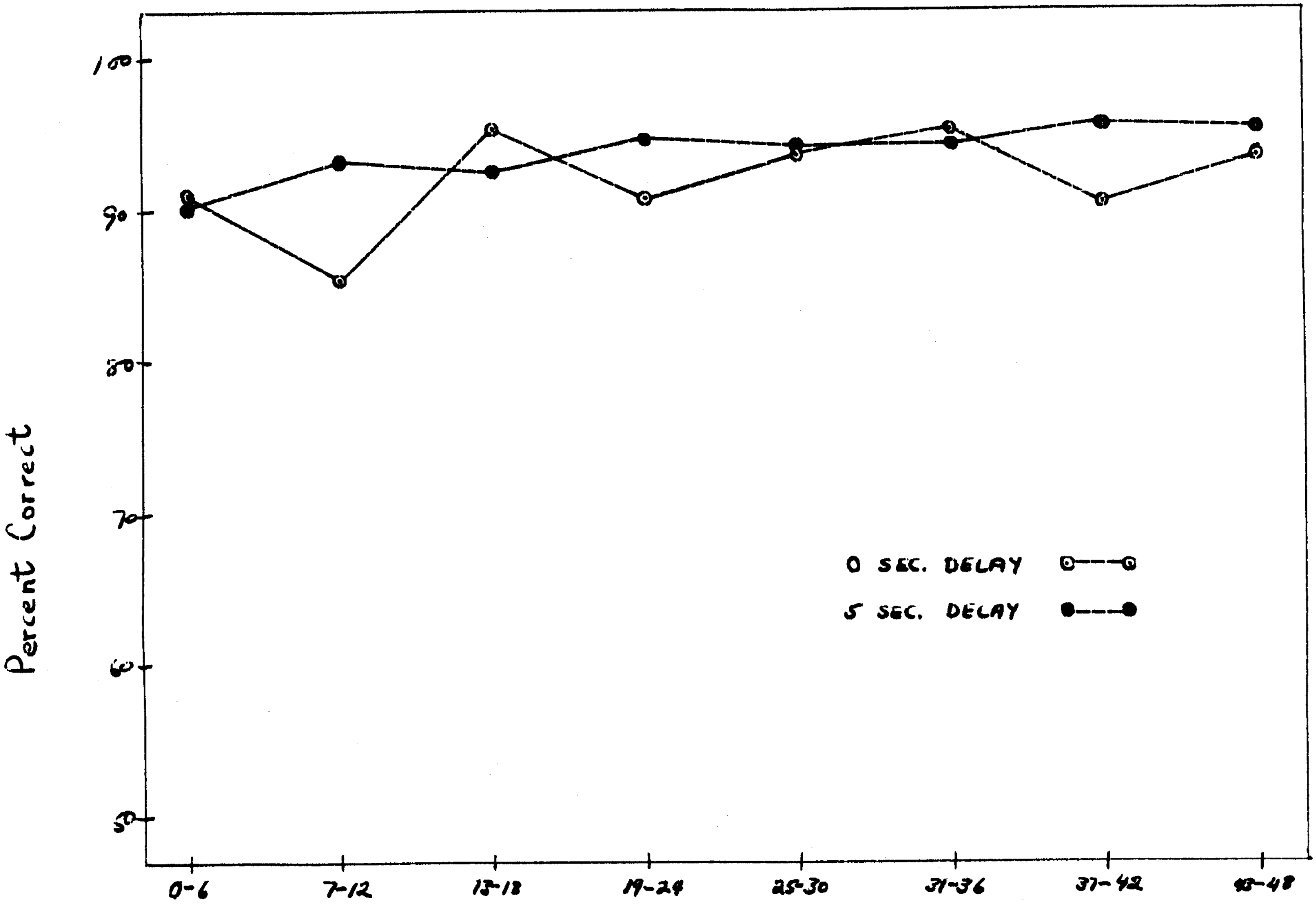



FIGURE 4 SIX HOUR BLOCKS OF TESTING

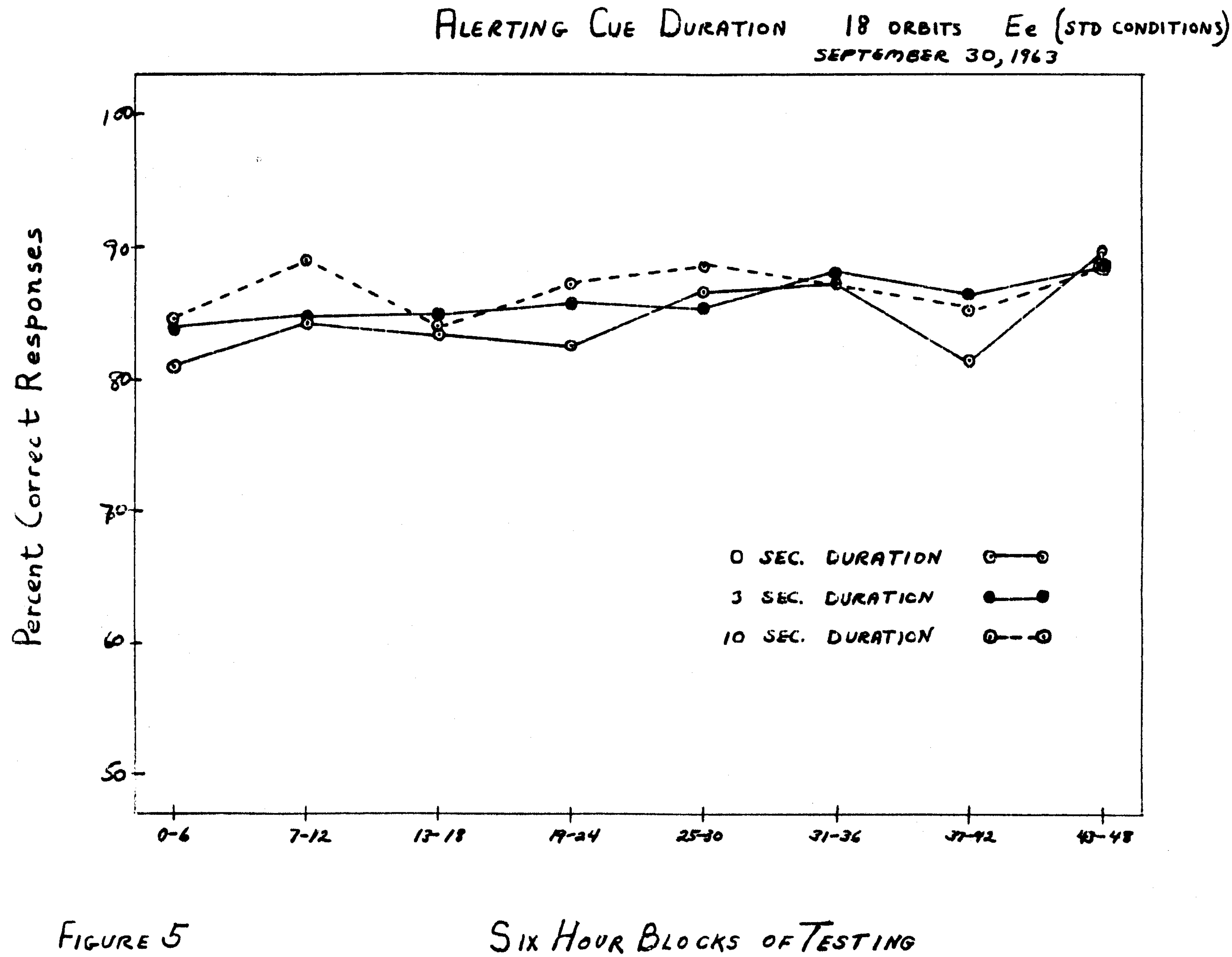

ALERTING CUE DURATION 18 ORBITS Ee (STD CONDITIONS)
SEPTEMBER 30, 1963
Percent Correct Responses
100
90
80
70
60
50
0-6
7-12
13-18
19-24
25-30
31-36
37-42
43-48
Six Hour Blocks of Testing
0 SEC. DURATION
3 SEC. DURATION
10 SEC. DURATION

FIGURE 5

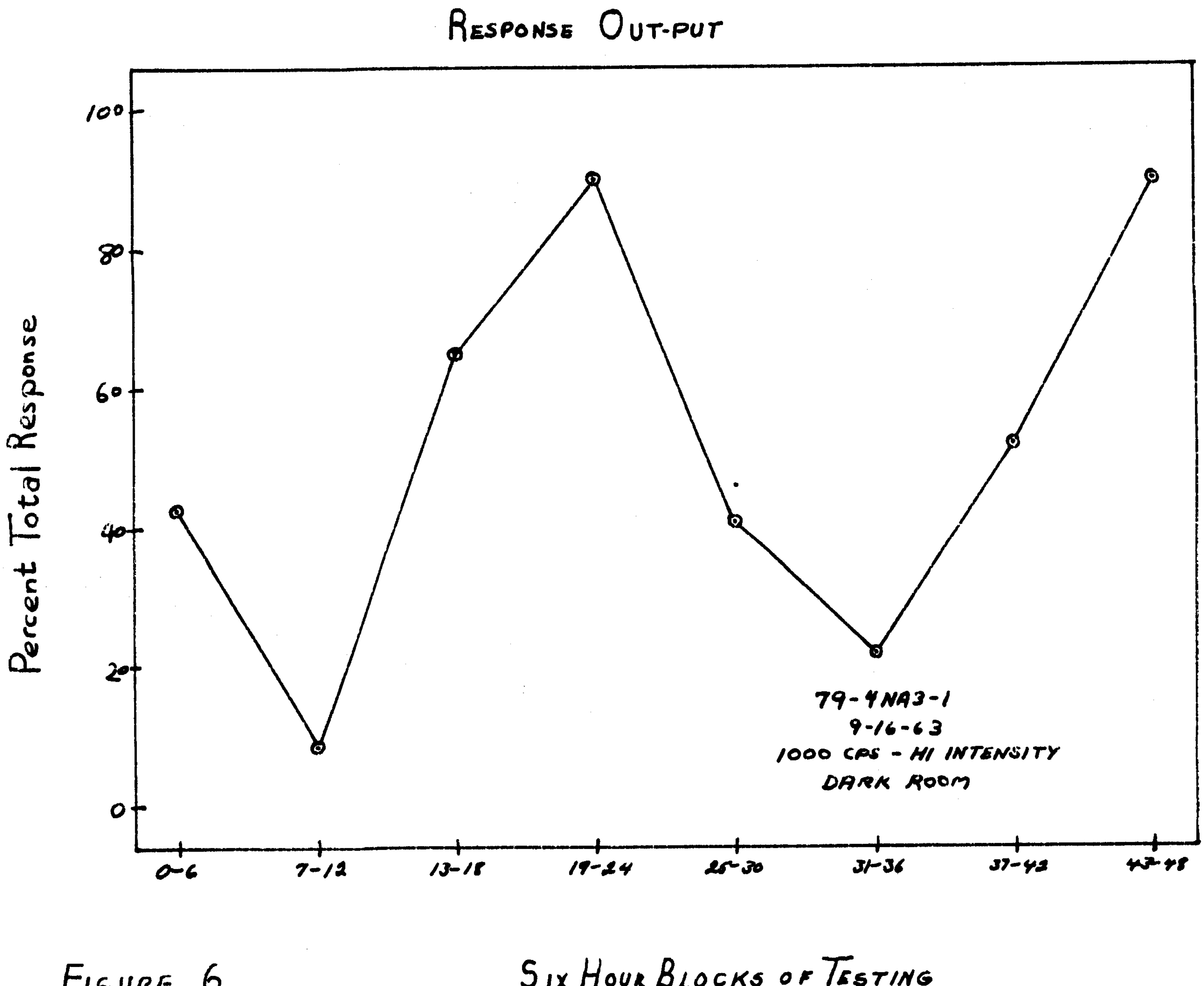

RESPONSE OUT-PUT
Percent Total Response
100
80
60
40
20
0
0-6
7-12
13-18
19-24
25-30
31-36
37-42
43-48
79-4NA3-1
9-16-63
1000 CPS - HI INTENSITY
DARK ROOM
SIX HOUR BLOCKS OF TESTING

FIGURE 6

RESPONSE OUT-PUT

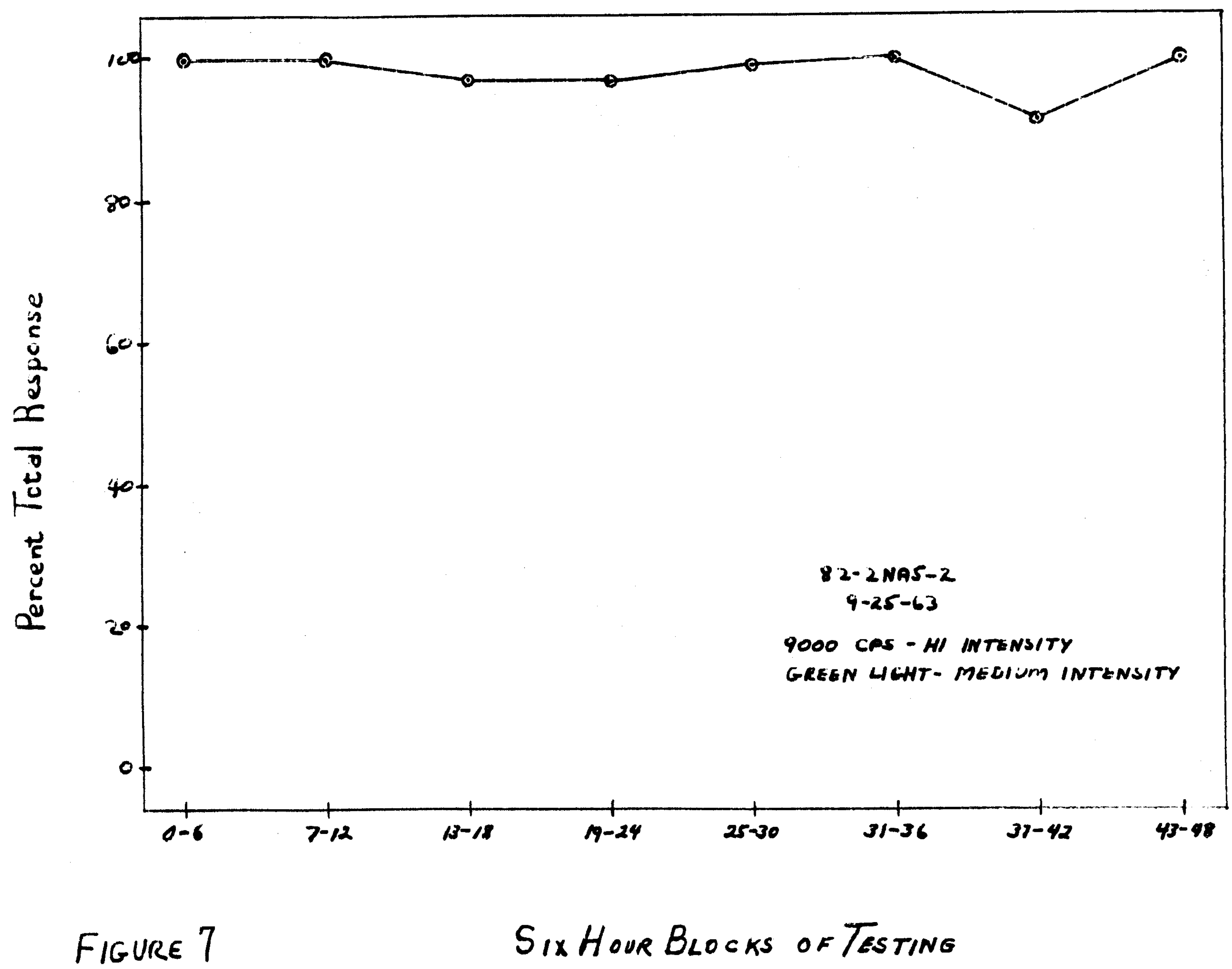



FIGURE 7

RESPONSE OUT-PUT

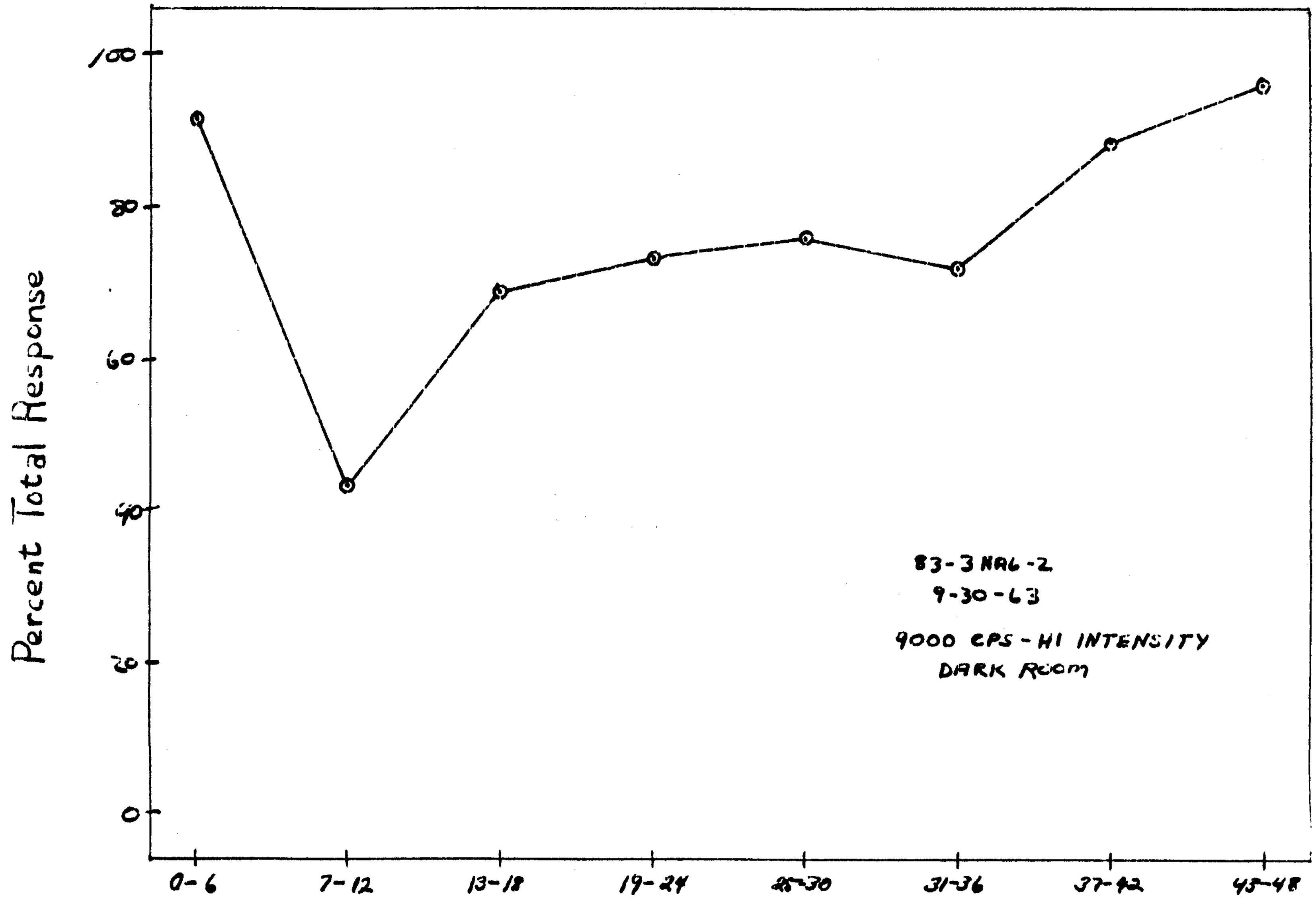
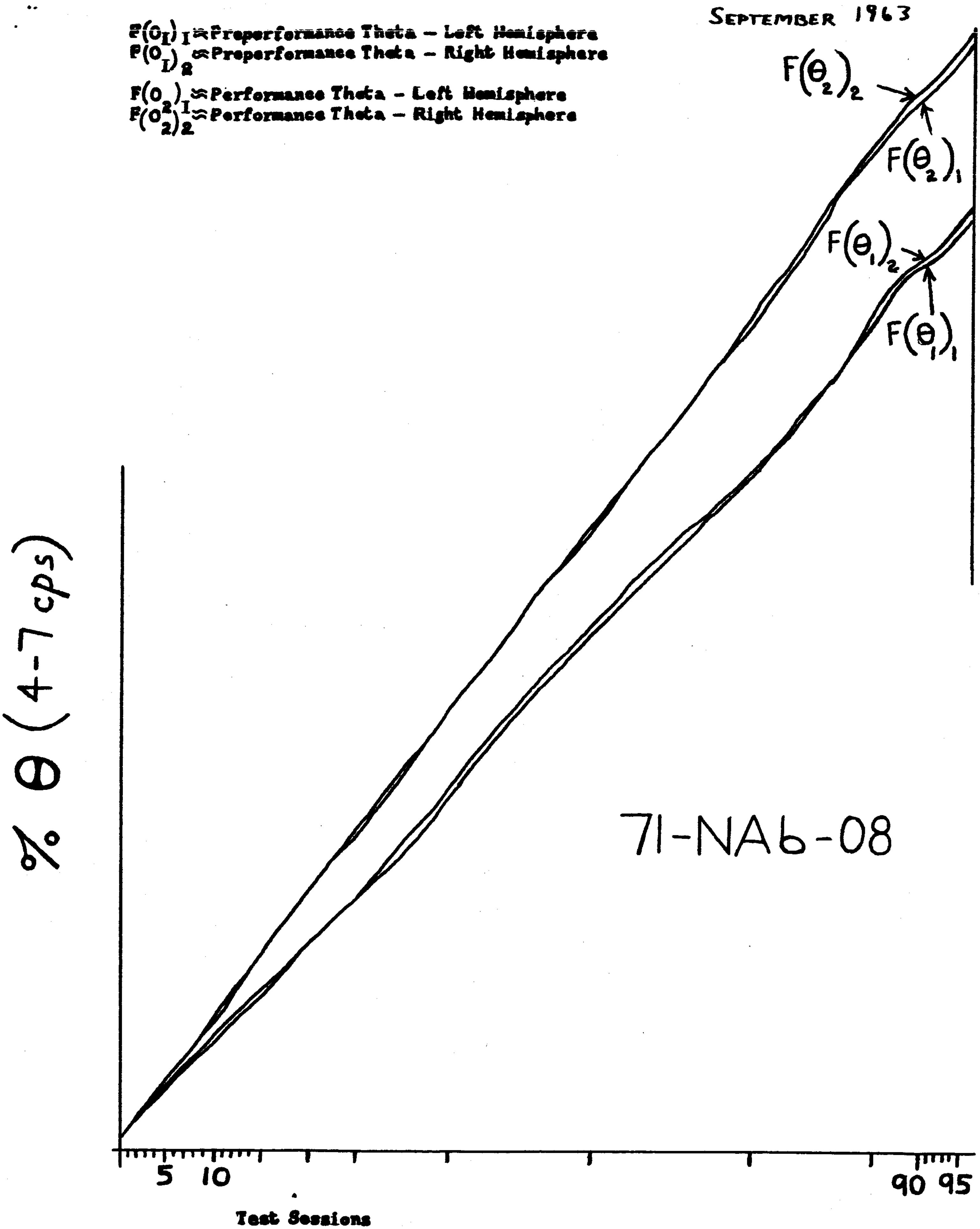



FIGURE 8

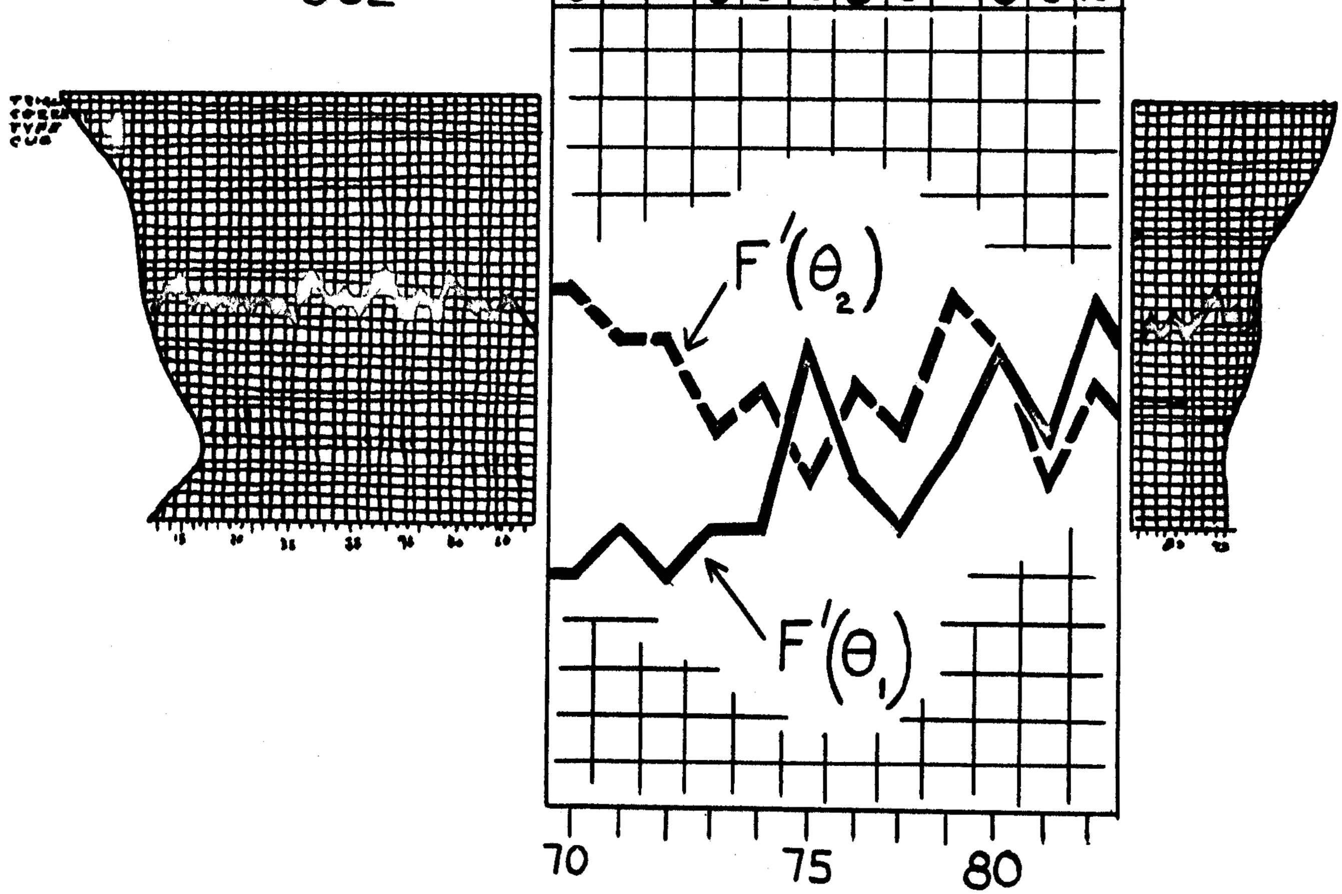
SIX HOUR BLOCKS OF TESTING



SEPTEMBER 1963
F(OI)I ≈ Preperformance Theta - Left Hemisphere
F(OI)2 ≈ Preperformance Theta - Right Hemisphere
F(O2)I ≈ Performance Theta - Left Hemisphere
F(O2)2 ≈ Performance Theta - Right Hemisphere
F(θ2)2
F(θ2)1
F(θ1)2
F(θ1)1
% θ (4-7 cps)
71-NA6-08
5
10
90
95
Test Sessions


FIGURE 9

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TRIALS | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| CORRECT | 8 | 7 | 6 | 8 | 8 | 8 | 6 | 7 | 8 | 8 | 8 | 7 |
| TYPE | R | D | R | D | R | D | R | D | R | D | R | D |
| CUE | 3 | 0 | 10 | 3 | 0 | 10 | 3 | 0 | 10 | 3 | 0 | 10 |

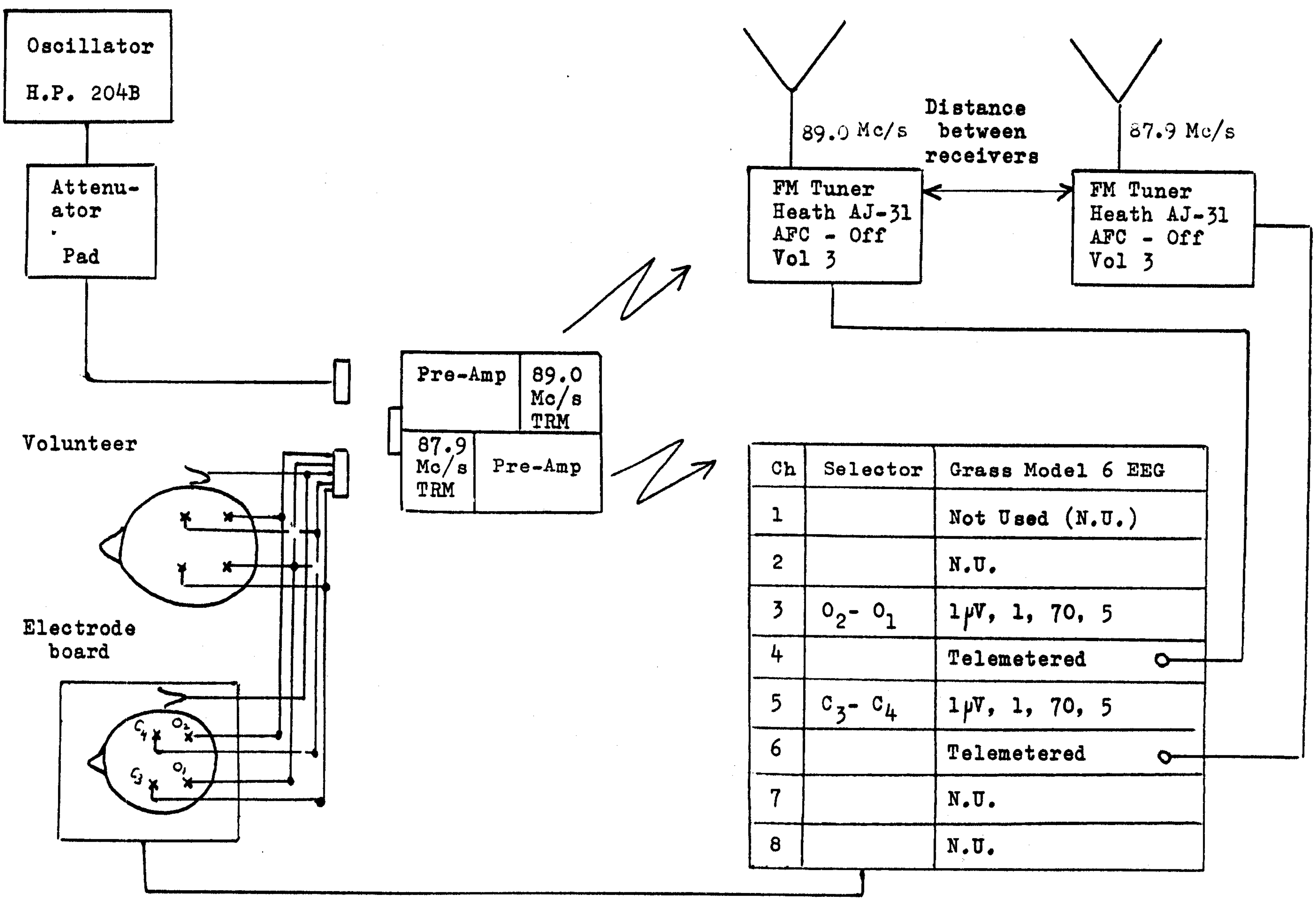



GRAPH OF THE FIRST DERIVATIVE

FIGURE 10

Arrangement of equipment

SEPTEMBER 1963




| Ch | Selector | Grass Model 6 EEG |
|---|---|---|
| 1 | | Not Used (N.U.) |
| 2 | | N.U. |
| 3 | $O_2 - O_1$ | 1μV, 1, 70, 5 |
| 4 | | Telemetered |
| 5 | $C_3 - C_4$ | 1μV, 1, 70, 5 |
| 6 | | Telemetered |
| 7 | | N.U. |
| 8 | | N.U. |

FIGURE 11

SEPTEMBER 1963

Dynamic range of the transmitter-receiver system

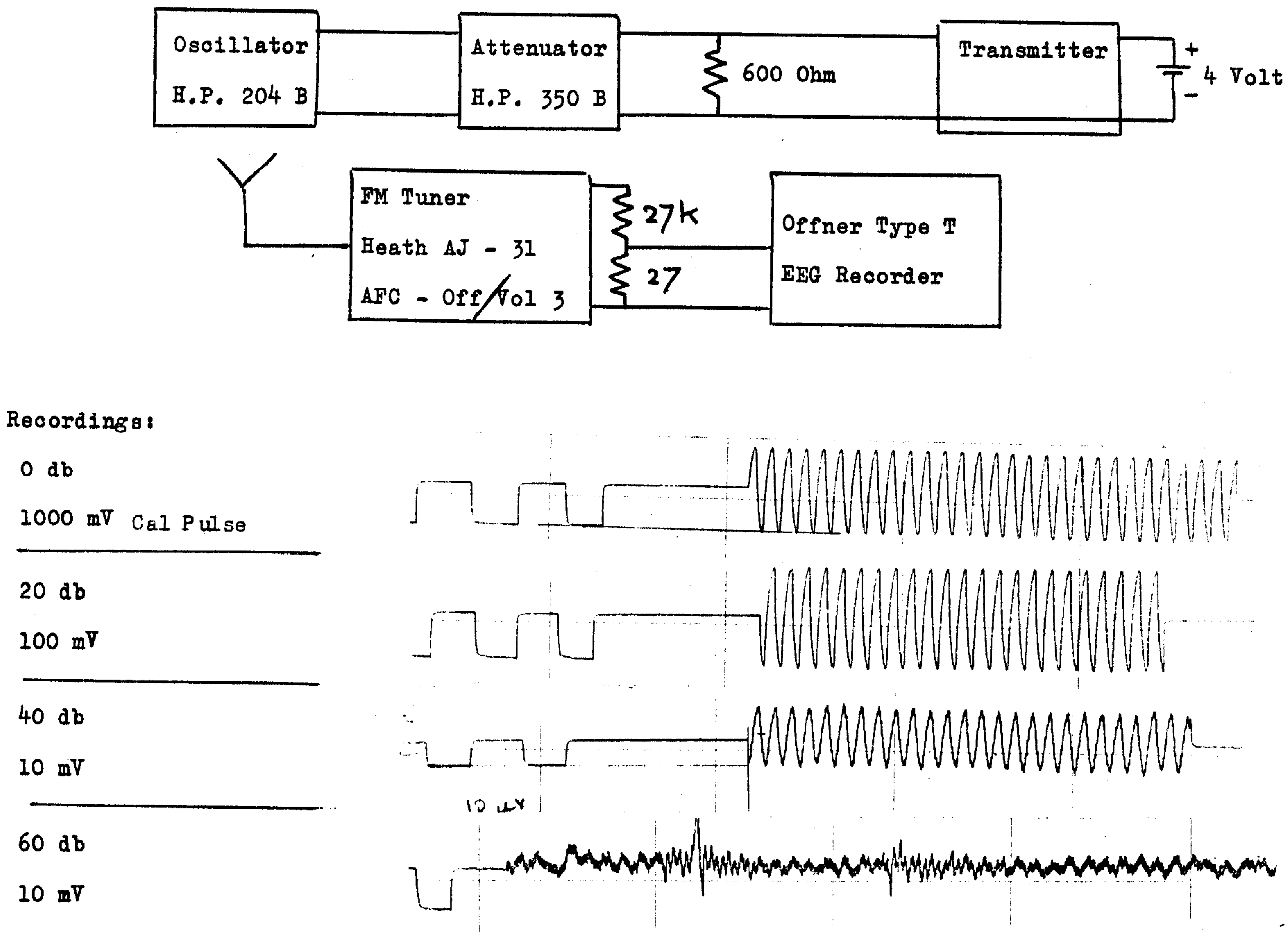
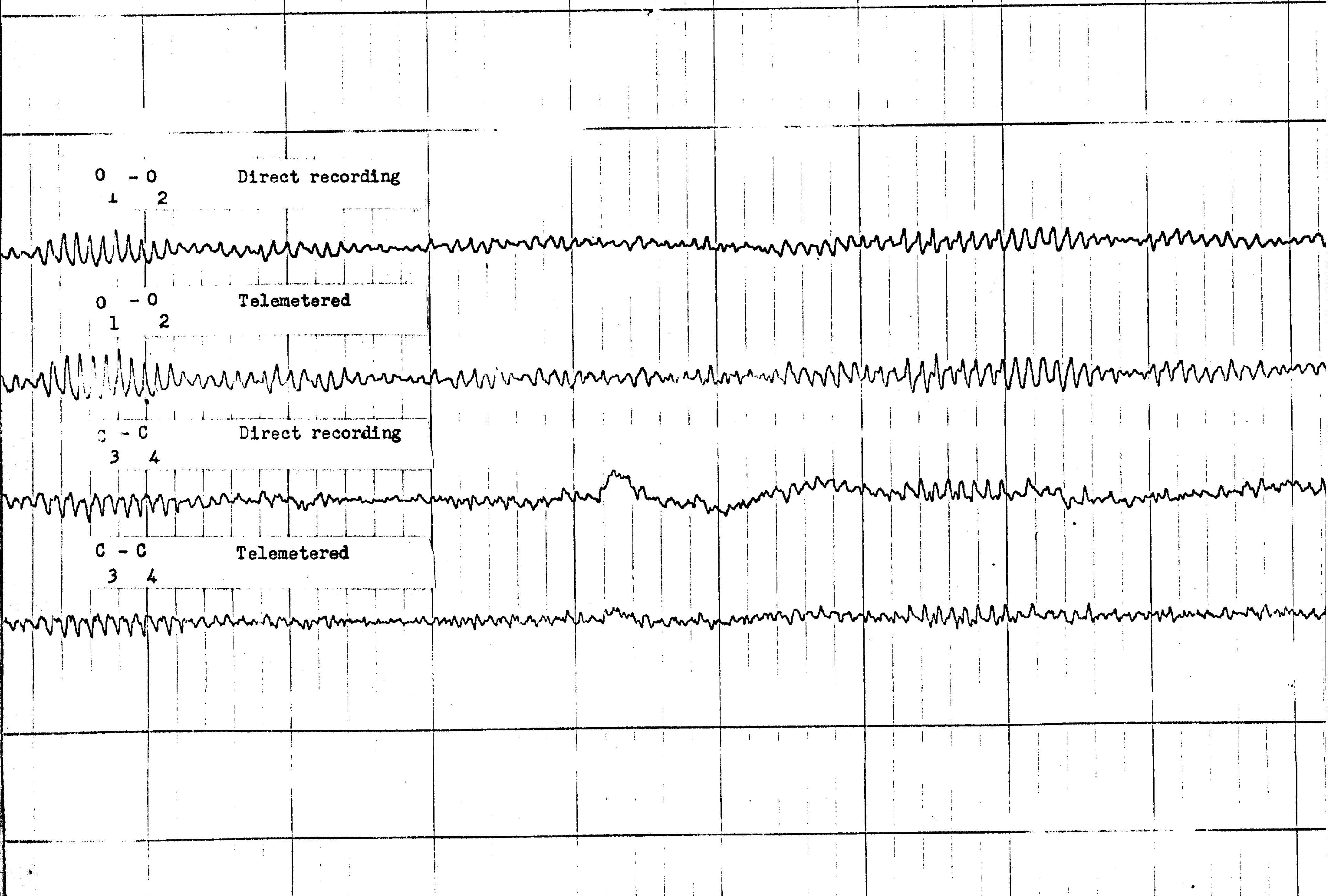



FIGURE 12

Fig. 13.

September 30, 1963



SEPTEMBER 1963

TABLE 1 Receiver interaction

| Amplitude of ink trace peak to peak in mm | | Channel 4 | | Channel 6 | | Distance between receivers |
|---|---|---|---|---|---|---|
| | | 89.0 Mc/s Pre-Amp Gain Setting | | | | |
| | | Min | Max | Min | Max | |
| 87.9 Mc/s Pre-Amp Gain Setting | Min | 2.0 | 12.0 | 2.0 | 2.0 | 6 inches |
| | Max | 6.5 | 15.5 | 13.5 | 13.5 | |
| | Min | 2.0 | 15.5 | 2.0 | 2.0 | 2 feet |
| | Max | 2.0 | 15.5 | 13.5 | 13.5 | |